



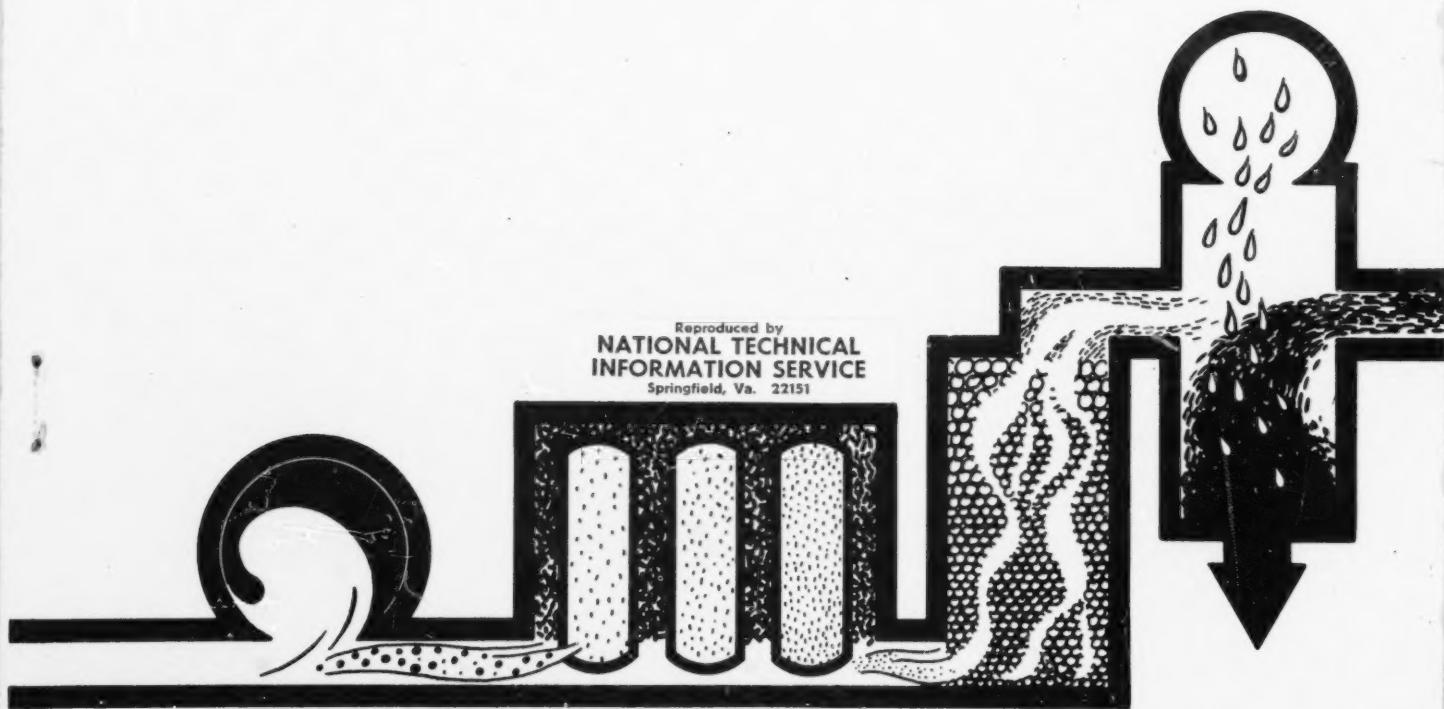
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INTEGRATED ACTIVATED SLUDGE BIOLOGICAL FILTER PROCESS

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27 Abstract A 75,000-gallon per day pilot plant was constructed at the City of San Buenaventura's Eastside Water Reclamation Facility, to evaluate the feasibility of treating domestic wastewaters by combining the two established processes of trickling filtration and complete mixed activated sludge. These processes were combined and evaluated according to the following three flow schemes:

- (1) Primary Sedimentation, Activated Sludge, Intermediate Sedimentation, Trickling
Filter, and Final Sedimentation;
- (2) Primary Sedimentation, Activated Sludge, Trickling Filter, and Final Sedimentation;
- and (3) Primary Sedimentation, Trickling Filter, Activated Sludge, and Final Sedimentation.

Mechanical problems with equipment and the lack of process control during operation of
Flow Scheme No. 1 were responsible for the unstable conditions and unreliable data.

The performance of Flow Scheme No. 2 was seriously affected by the lack of concentrated
return activated sludge due to floc dispersal, and loss of solids to the final effluent
as a result of the mixed liquor passing over the trickling filter.

Flow Scheme No. 3 was stabilized and meaningful data was in the process of being collected
when a major flood on the Santa Clara River inundated the entire water reclamation
facility and pilot plant. Preliminary data indicated that this flow scheme is the most
promising combination of the trickling filtration and activated sludge processes.

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INTEGRATED ACTIVATED SLUDGE
BIOLOGICAL FILTER PROCESS

by

City of San Buenaventura,
California

for the

WATER QUALITY OFFICE
ENVIRONMENTAL PROTECTION AGENCY

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ABSTRACT

A 75,000 gallon per day pilot plant was constructed at the City of San Buenaventura's Eastside Water Reclamation Facility to evaluate the feasibility of treating domestic wastewaters by combining the two established processes of trickling filtration and complete mixed activated sludge. These processes were combined and evaluated according to the following three flow schemes:

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Flow Scheme No. 3 was stabilized and meaningful data was in the process of being collected when a major flood on the Santa Clara River inundated the entire water reclamation facility and pilot plant. Preliminary data indicated that this flow scheme is the most promising combination of the trickling filtration and activated sludge processes.

This report was submitted in fulfillment of Grant No. WPRD 2-01-67 between the Environmental Protection Agency and the City of San Buenaventura, California.

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SECTION I

CONCLUSIONS

1. The most promising flow scheme for combining the activated sludge and trickling filter unit processes appears to be the one in which the trickling filter precedes the activated sludge process. This sequence of process operation tends to eliminate severe fluctuations in BOD applied to the aeration system.
2. The trickling filter following the activated sludge process dispersed the biological floc, thus hindering its settling characteristics and causing a loss of active solids to the final effluent. This dispersal of floc was even greater when mixed liquor was passed directly over the trickling filter as occurred when bypassing the intermediate sedimentation tank.

SECTION II

RECOMMENDATIONS

The "Integrated Activated Sludge - Biological Filter Process" pilot plant project was not completed as envisioned in the project objectives. However, preliminary results indicated that trickling filtration preceding activated sludge was the most feasible sequence of unit process operation. Support data is limited due to minimum data collection, problems with pilot plant equipment, and interruption of the project due to the flood.

Therefore, the following recommendations are applicable:

1. The integrated process of trickling filtration preceding activated sludge should be further evaluated. The major objectives should include a determination of optimum loading rates, design parameters, and associated costs.
2. Conventional equipment with maximum finite control should be incorporated into the pilot plant. This is especially true for return activated sludge and air diffusion equipment.
3. The pilot plant should undergo a 3-month preliminary trial utilizing each major unit process separately, to evaluate individual process performance and control, prior to series operation.
4. The project's direct supervisor should have sufficient experience and prior association with research to foresee problems that might exist and to see that sufficient data is collected for final evaluation.
5. Operating personnel should be available for seven days per week pilot plant attention. Critical samples required for process evaluation should be taken seven days per week.
6. Complete and verified laboratory data should be kept separate from the data summaries. Notations should be made along with all data entries as to physical appearance of the process and the reliability of particular data if it should depart substantially from the expected norm.

SECTION III

INTRODUCTION

In 1958 the City of San Buenaventura constructed the Eastside Water Reclamation Facility adjacent to a lagoon formed at the mouth of the Santa Clara River. The treatment process consists of primary clarification and two-stage, high-rate trickling filtration. The final effluent is discharged into holding ponds and utilized for irrigation of the City owned Olivas Golf Course with excess flows directed to the Santa Clara River lagoon.

Due to the increasing flows, as a result of rising population, and the increasing recreational attractiveness of the lagoon, delineation of expansion possibilities was essential. The existing plant had a limited amount of space for the forthcoming expansion and since trickling filters require large land areas a combination of activated sludge (less land, higher efficiency) with the existing filters had to be considered.

Knowing that other communities could possibly face the same expansion problems and based upon previous reported results regarding activated sludge combined with high-rate trickling filtration (1), the City of San Buenaventura applied to the Federal Water Pollution Control Administration for a demonstration grant to evaluate the feasibility of an integrated activated sludge-trickling filter system and thusly provide general design and operational data applicable to similar situations throughout the country.

The agreement reached between the Federal Water Pollution Control Administration and the City of San Buenaventura provided for a research and development grant of \$90,226 to be awarded for a project entitled, "Integrated Activated Sludge-Biological Filter Process." The City of San Buenaventura agreed to fund 25 percent or \$30,075 of total project cost of \$120,301.

A 75,000 gallon per day pilot plant was constructed on the grounds of the Eastside Water Reclamation Facility. The pilot plant included primary sedimentation, a high-rate trickling filter, activated sludge treatment, intermediate and final sedimentation and associated equipment items.

The program goal was to develop data and demonstrate the reliability, engineering, operating and economic potential of a biological domestic wastewater treatment process employing series combinations of the trickling filter and activated sludge processes. It was planned that the most feasible combination of processes would be determined based upon the success or failure of the following three flow schemes:

1. Primary clarification, activated sludge, intermediate clarification, trickling filtration, and final clarification (Figure 1).
2. Primary clarification, activated sludge, trickling filtration, and final clarification (Figure 2).

3. Primary clarification, trickling filtration, activated sludge, and final clarification (Figure 3).

The preceding flow schemes were to be evaluated over a nine month period with a maximum of three months each, to obtain preliminary data, unless technical judgement and data indicated non-feasibility after a shorter period. The most promising system, based upon the cursory investigation, was then to be evaluated for an additional three months or the remaining part of the year, whichever was greater.

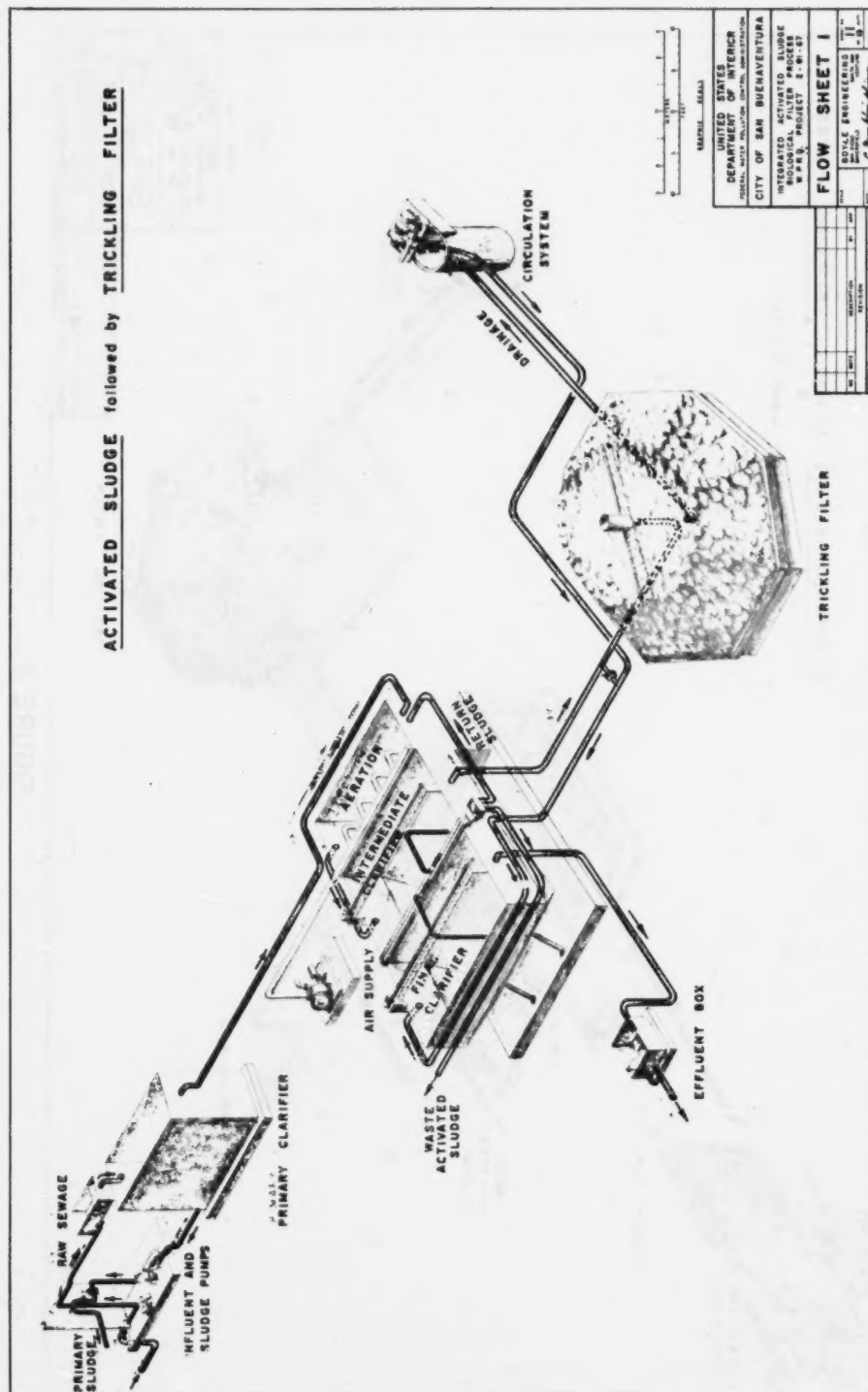


FIGURE I

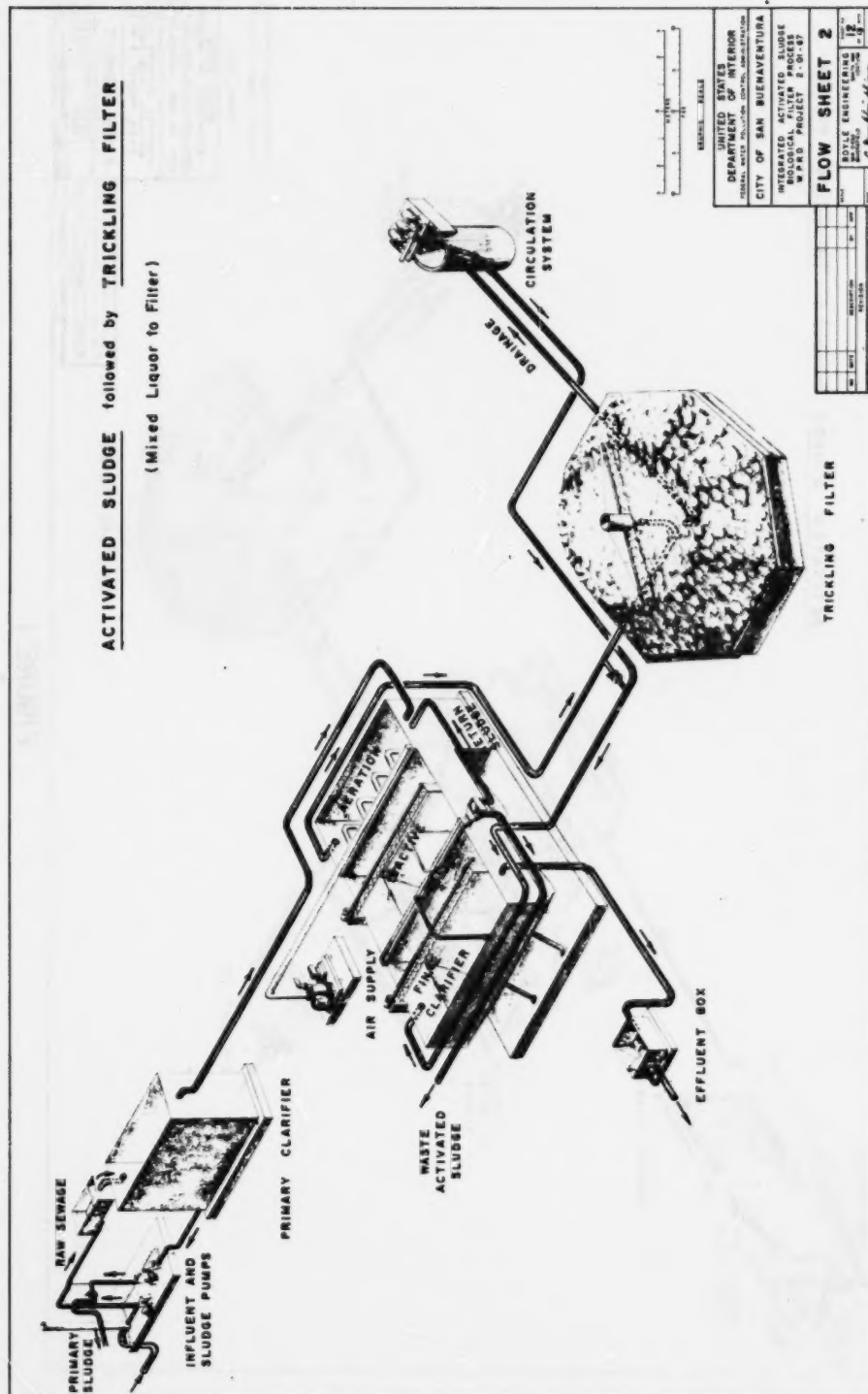


FIGURE 2

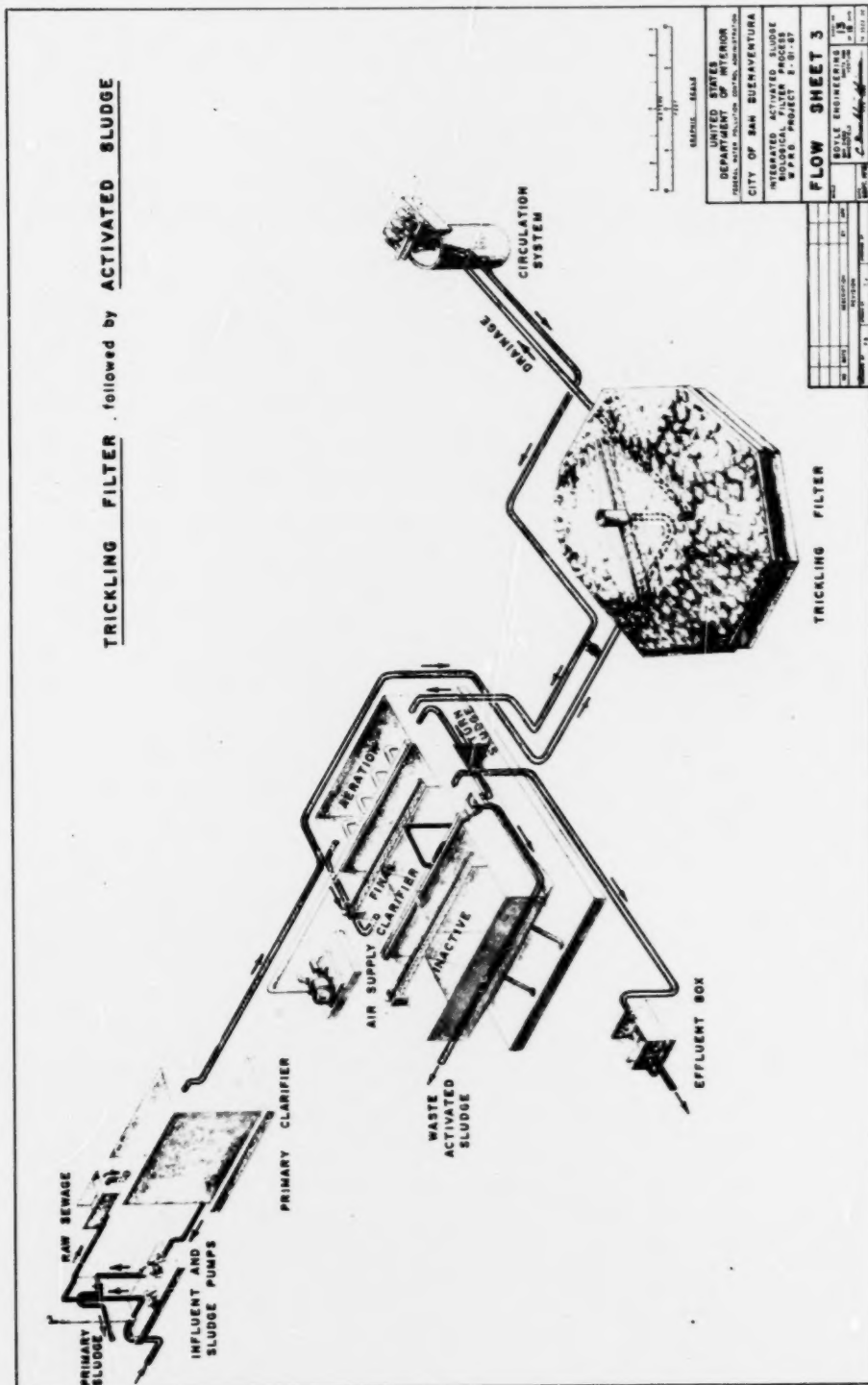


FIGURE 3

SECTION IV

DESIGN AND CONSTRUCTION

General

The pilot plant treatment facility general layout is shown in Figure 4, and was constructed adjacent to the existing Reclamation plant's primary clarifier to facilitate removal of primary sludge and skimmings. Also in Figure 4 is the mechanical equipment schedule listing a description of the item and its manufacturer. Construction of the pilot plant began on June 9, 1967 and was completed during the first week of March 1968.

Table 1 is the Project Design Summary which lists the design parameters and raw sewage characteristics utilized in sizing the various pilot plant units.

Figure 5 is a photograph showing the pilot plant installation.

Preliminary Treatment and Influent Pumping

Raw sewage enters the Eastside Water Reclamation Facility through a 36-inch pipe and is comminuted by two Chicago Pump Model "B" barminutors and then discharged into a wet well. Raw sewage is then pumped into a 24-inch force main to the primary clarifier. That force main was tapped and a four-inch line installed to feed the pilot plant as shown in Figure 4. The pressure head on the force main at the point of tap was approximately ten feet.

The four-inch force main terminated in a stand pipe. A two-inch Wemco Model "A" horizontal pump was used to lift comminuted raw sewage from the stand pipe to the pilot plant influent weir box. Details of the influent weir box are shown in Figure 6. Due to the characteristics of the Wemco pump the flow would fluctuate in accordance with the varying stand pipe level, which was proportional to plant flow, and variable speed pumps were not considered necessary.

Primary Sedimentation

The design of the primary clarifier was predicated on maintaining a two-hour detention time and a surface loading rate of 960 gpd/ft². These values, perhaps conservative, were selected to avoid problems of short circuiting normally encountered at pilot plant scale.

The raw sewage entered the primary clarifier through an energy dissipator, which was simply a twelve-inch pipe with slotted openings installed perpendicular to the tank flow. The dissipator was designed to direct the incoming flow downwards at low velocities. Drawings showing the construction and installation of the flow dissipator are detailed in Figure 7.

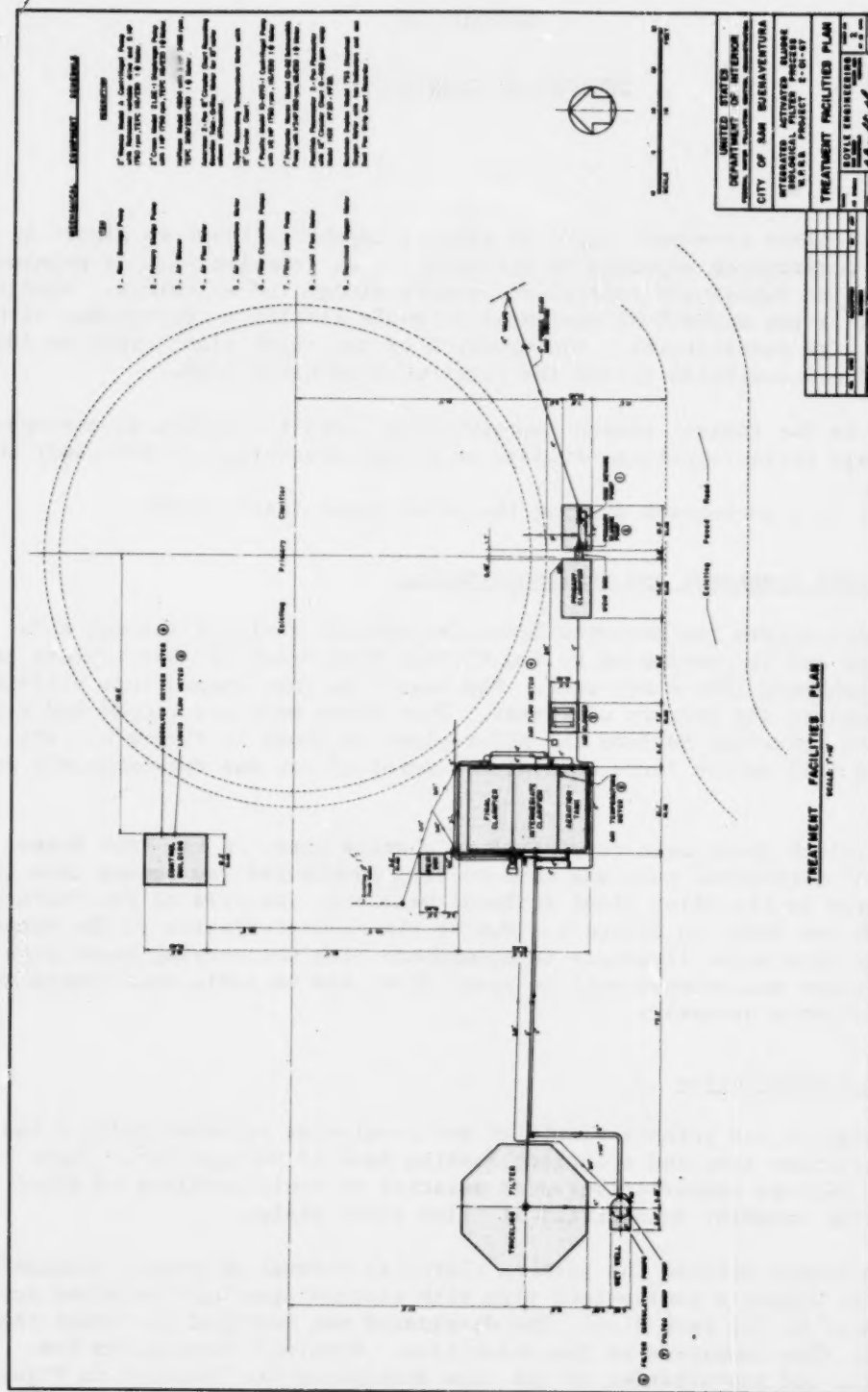


FIGURE 4

TABLE 1

Project Design Summary

Sewage characteristics and quantity:

1. Research Plant Design Flow	75,000 gpd
2. Raw Sewage 5-day 20°C BOD	225 mg/l
3. Primary Effluent BOD (35% Removal)	146 mg/l
4. Type Sewage	Domestic

Treatment Units:

1. Primary Clarifier	
Surface Area	78 sf
Surface Loading	960 gpd/sf
2. Trickling Filter	
Filter Dimensions	
Diameter	20 ft.
Rock Depth	6 ft.
Volume	1,860 cf
Surface Area	310 sf
Hydraulic Loading	242 gpd/sf
Volumetric Loading (91 lb./day, 5-day 20°C BOD)	49 lb./1000 cf
3. Activated Sludge	
Volume	1,190 cf
Volumetric Loading (91 lb./day, 5-day 20°C BOD)	76.5 lb./1000 cf
4. Secondary Clarifier	
Surface Area	210 sf
Surface Loading	350 gpd/sf

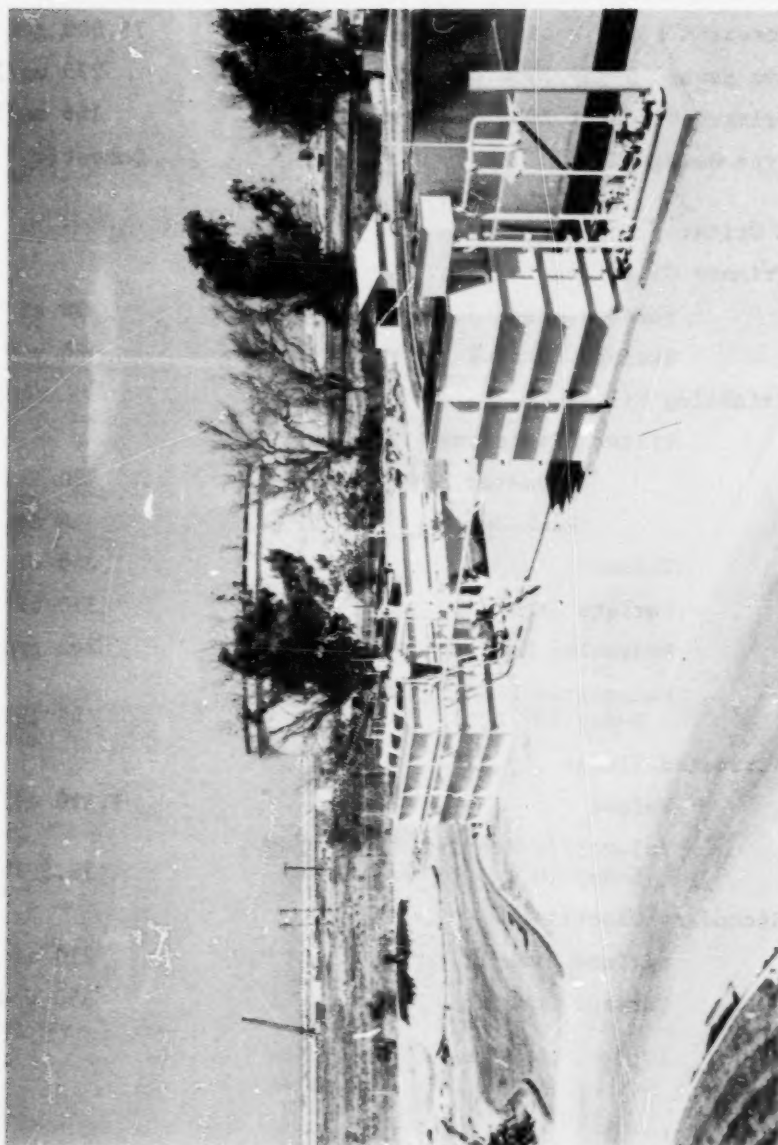
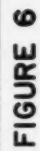
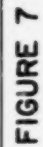


FIGURE 5 - PILOT PLANT FACILITY





The sludge collection system was a chain and flight type since the clarifier was rectangular. The chains were manure spreader chain with 1/2 in. x 2 in. redwood flights. The flights were driven at a speed of three feet per minute by a Westinghouse 1/4 HP, 115 V-AC, 1725 RPM, motor through a gear reducer and subsequent drive sprocket assembly. Details showing the drive unit, speed reducer, and the chain and flight are shown in Figure 8. The sludge collector hopper was at the entrance side of the clarifier. The flights were positioned to serve also as skimmers on the primary clarifier. All skimmings were manually removed from the primary clarifier. The primary sludge was removed from the process and added to the Eastside Water Reclamation Facility's primary clarifier.

The effluent from the primary clarifier passed over a straight weir and flowed into a four-inch pipe. The four-inch pipe had valving flexibility, as shown on the system piping layout in Figure 9, to feed the activated sludge system or the trickling filter.

The pilot plant primary clarifier was prefabricated in a metal shop and installed on the foundation prepared by City forces. Concrete slab details are shown in Figure 10.

Activated Sludge System

The activated sludge aeration tank design was based upon a loading of 76.5 lb. of 5-day BOD per 1,000 cfd. This required an aeration tank size of 1,190 cu.ft. when the primary effluent average BOD was 91 lb/day. The mean detention time based upon a 75,000 gpd flow rate was 2.85 hours.

Four diffuser headers were placed in the center of the aeration tank as shown in Figure 9. Initially the diffusers were the Chicago Pump flexo-fuser sock type, however, these were later replaced with coarse bubble diffusers designed and constructed by the plant staff. A drawing of the diffuser constructed is shown in Figure 11. The first two headers contained six diffusers each, and the second two, four each.

The replacement of the diffusers was necessary after completing the first flow scheme due to difficulty in operating the centrifugal blower at its maximum rated head. It was felt that the semi-fine bubble diffusers, combined with the flow meter orifice, were causing excessive head. Changing diffusers was determined to be the simplest way to reduce the back pressure on the blower.

During initial testing, difficulty was encountered with too much air. The blower, being of the centrifugal type, was sensitive to changes in temperature and density which made it virtually impossible to manually control dissolved oxygen levels to the degree required. It was decided to install an automatic system for controlling the dissolved oxygen content in the system. A schematic diagram of the system is shown in Figure 12. A dissolved oxygen probe was placed in a stilling well at the terminus of the aeration tank. The stilling well was designed so that air being diffused through the system would not interfere with the actual dissolved

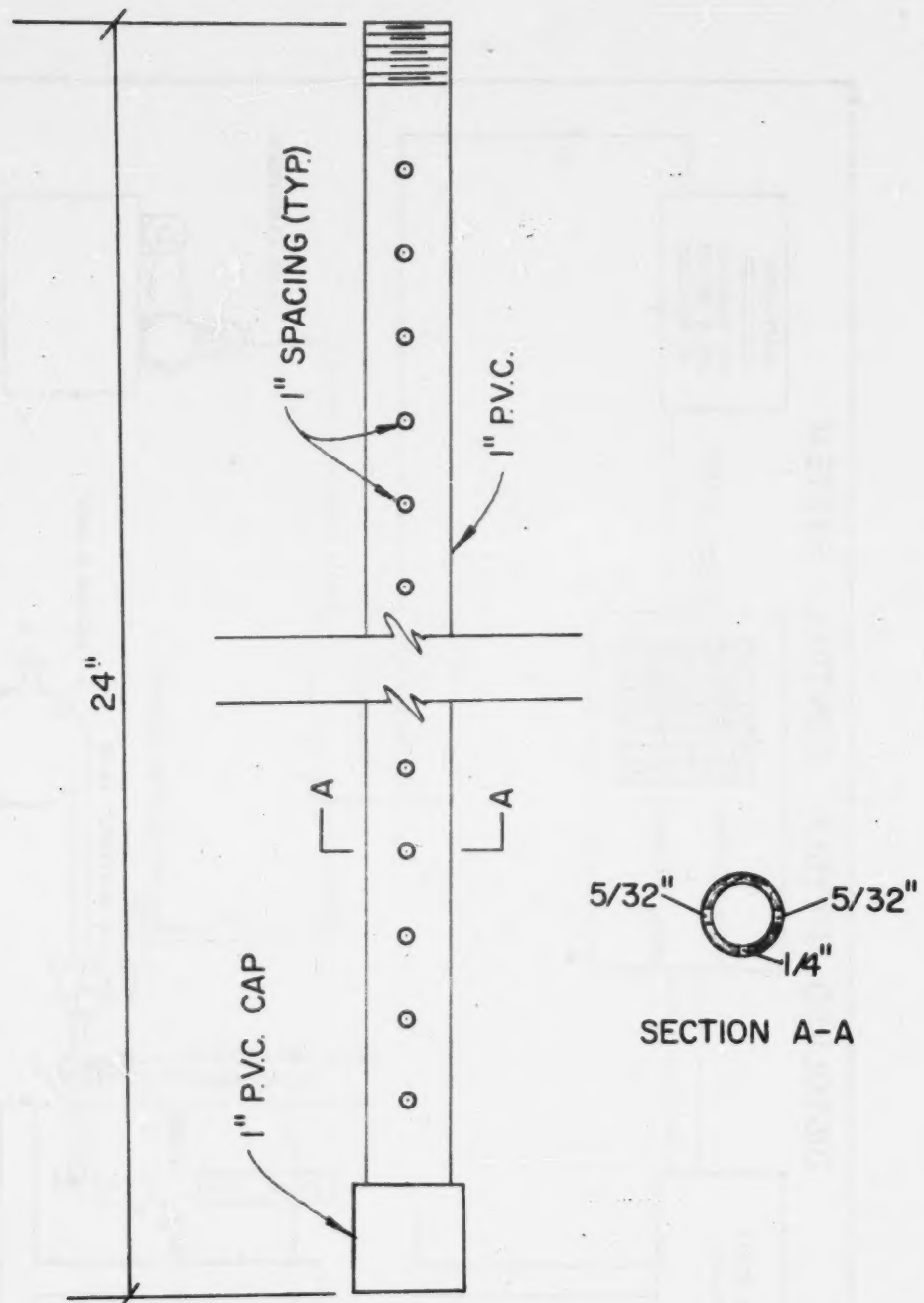


FIGURE 11 - COARSE BUBBLE AIR DIFFUSER
NO SCALE

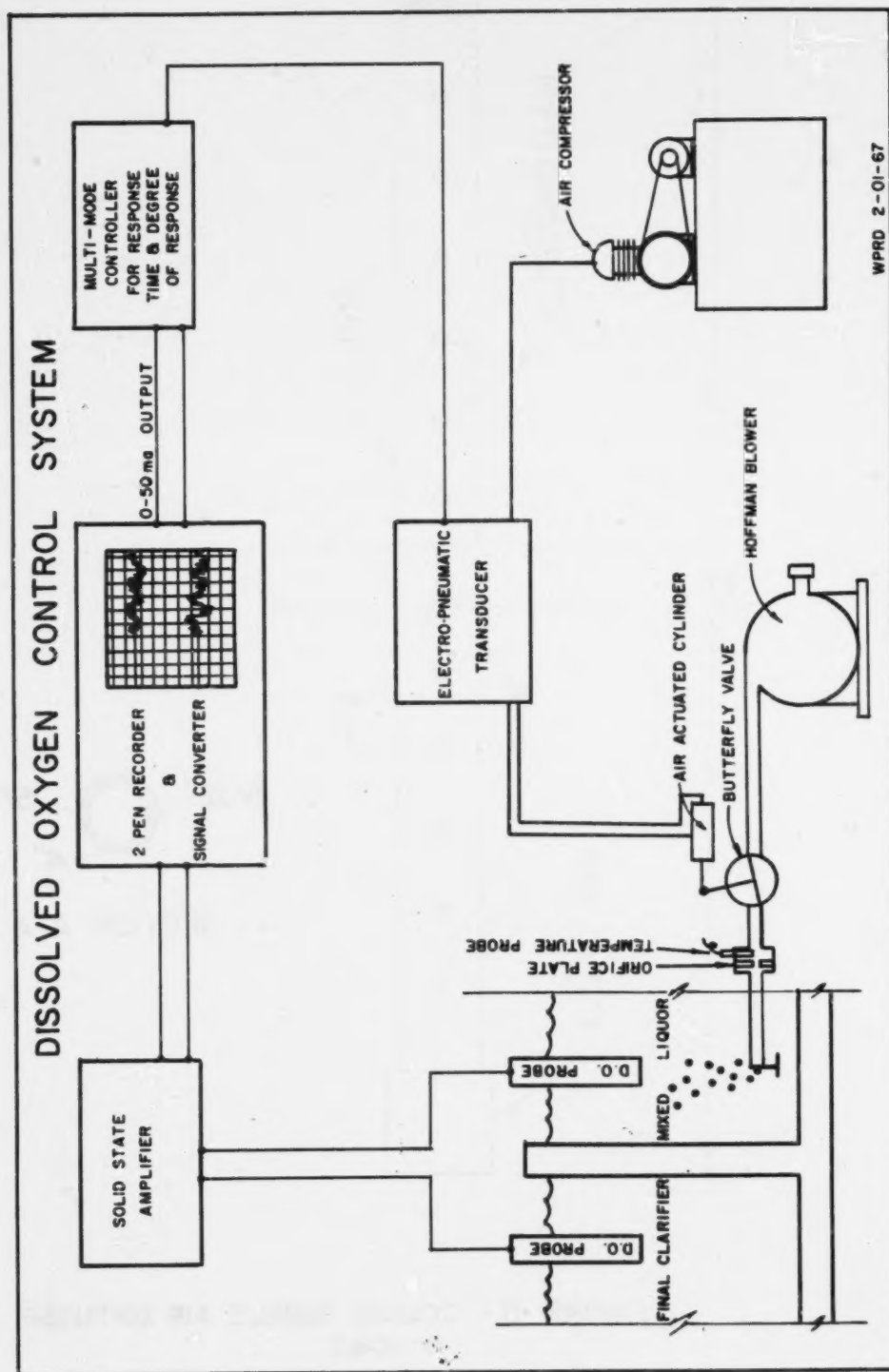


FIGURE 12

oxygen determinations. The dissolved oxygen was recorded and used to control airflow from the centrifugal blower. A multimode controller was installed between the sensor and an electropneumatic transducer, which controlled a butterfly valve on the discharge side of the blower. Through adjustment of the multimode controller, the proper lag and response time of the unit was controlled. (See Figure 12).

Intermediate Clarifier

The intermediate clarifier was designed for a surface overflow rate of 350 gpd/sq.ft. based upon the 75,000 gpd average flow. The unit was further designed such that the surface overflow rate and the detention time could be respectively increased or decreased. This was to be accomplished by placement of a water tight baffle in the tank. See Figures 9, 13, and 14 for intermediate clarifier details.

The sludge collection system was a Chicago Pump "Collectair," which utilized a traveling squeegee and a traveling airlift pump that discharged into a channel adjacent to the clarifier. The sludge trough system is shown in more detail in Figure 9. Sludge pumping could be controlled by adjustment of the air volume to the collectors or by a short cycle time clock operating a solenoid valve on the air supply line.

Final Clarifier

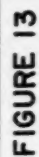
The final clarifier for the trickling filter was identical in configuration to the intermediate clarifier. The final clarifier, however, did not have the solenoid valve and time clock assembly which was primarily for controlling return activated sludge.

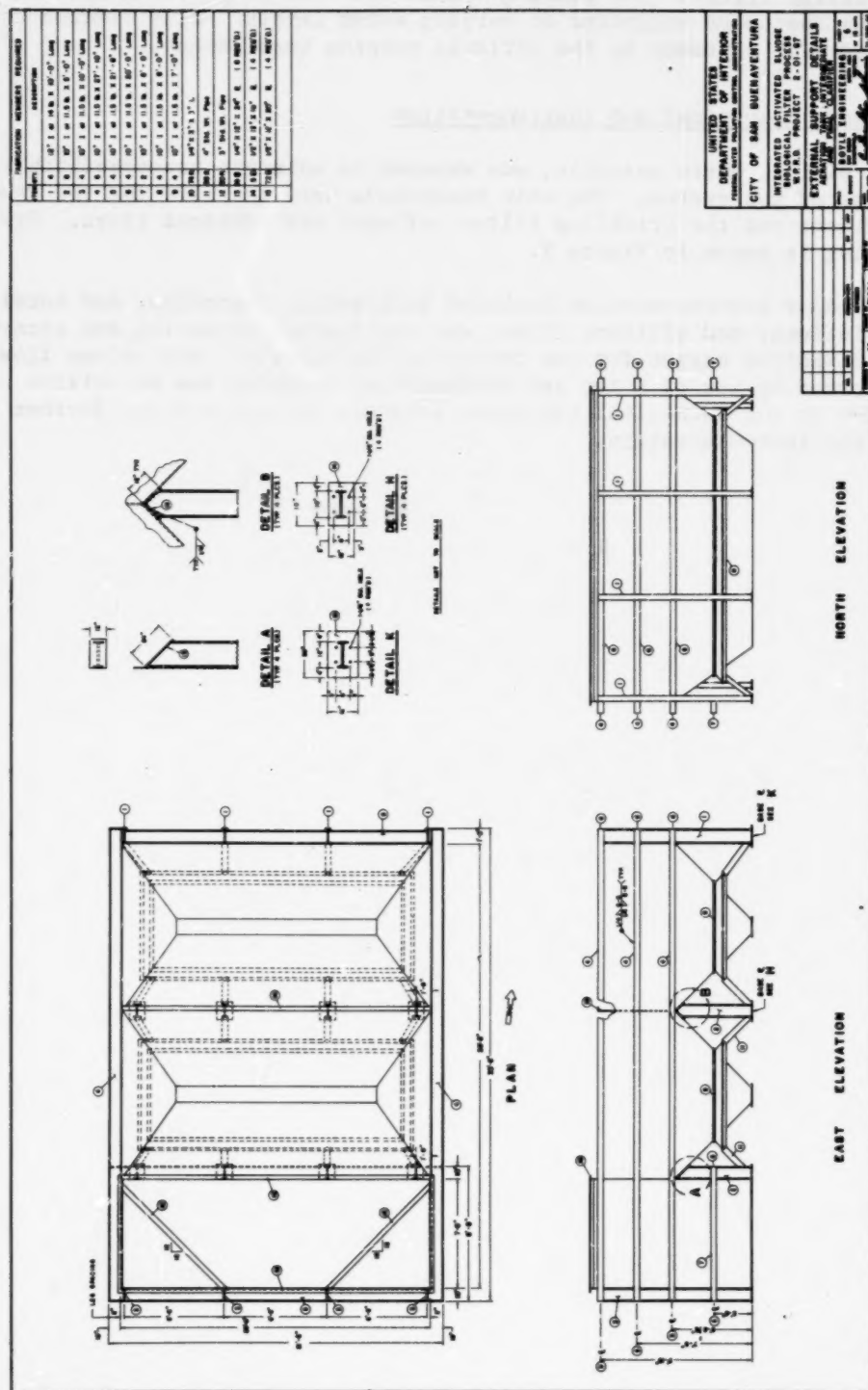
Trickling Filter

The pilot plant trickling filter was designed on the basis of loading approximately 49 lb of 5-day BOD per 1,000 cfd and design details are shown in Figures 8 and 10. The filter was twenty feet in diameter and six feet deep and thus, the surface loading rate was approximately 240 gpd/sq.ft. and the volumetric 5-day BOD loading was approximately 49 lb per 1,000 cu.ft. Both loadings were based upon 75,000 gpd with 91 lb of 5-day BOD per day in the primary effluent.

The filter was constructed entirely by the City staff. A redwood timber grillage was constructed on a concrete foundation and locally available blast furnace slag, approximately 2.5 inches in diameter, was used as the filter media. The unit was constructed to preclude the necessity for side walls by increasing the base diameter to account for the angle of repose of the filter media. The rotary distributor mechanism was designed for the expected flows and was built in the City machine shop. Detailed drawings of the rotary distributor are shown in Figure 8.

Effluent was collected at the center of the supporting slab, as shown in Figure 10, and flowed to a 36-inch concrete sump located adjacent to the





trickling filter. The pumping system from the sump utilized three small pumps that were activated at varying water levels. This offered the most economical approach to the variable pumping requirement.

Piping, Electrical and Instrumentation

All piping, where possible, was exposed to maintain accessibility to every phase of the system. The only exceptions were the line for the raw sewage influent and the trickling filter influent and effluent lines. System piping is shown in Figure 9.

The major instrumentation included indicating, recording, and totalizing of influent and effluent flows, and continuous indicating and recording of dissolved oxygen for two points in the process. Air volume flows were recorded by use of a two pen differential recorder and an orifice plate. Refer to the Mechanical Equipment Schedule in Figure 4 for further details of the instrumentation.

SECTION V

PILOT PLANT PERFORMANCE

Activated Sludge, Intermediate Clarification and Trickling Filter

On Friday, March 8, 1968, the pilot plant was placed in operation. The first flow scheme established was primary sedimentation followed by activated sludge, intermediate clarification, trickling filter, and final clarification. The schematic flow diagram was previously shown in Figure 1.

The first problem encountered was the inability to get the required flow through the system piping. This was attributed to the fact that air locks were occurring in the piping between the primary clarifier and the aeration tank, in the piping between the trickling filter and the final clarifier, in the primary sludge line, and in the raw sewage influent line. Air vents were installed on the lines and an even flow through the system was affected.

The primary sludge pump, an electrically driven diaphragm pump, was of such a capacity that it pumped at a higher rate than the inflow, thus creating a stop in the primary clarification flow until the sludge pump ceased operating. The stroke was shortened and the pump was slowed down to a minimum to correct this problem. Minor equipment maintenance and instrument and weir calibrations were conducted until the first of May when it was determined that the pilot plant was functioning sufficiently well to begin evaluation of Flow Scheme No. 1.

In attempting to control the biological aspects of the system, primarily the mixed liquor suspended solids, the problem of too much air was encountered which resulted in sludge separation in the final clarifier. During the first part of May, it was determined that an air flow measuring device and a method of controlling the dissolved oxygen level in the system were necessary. The Southern Counties Gas Company provided a two pen differential recorder, an orifice plate and an air temperature recorder. However, the dissolved oxygen control system as described in the preceding section and shown in Figure 12 was not installed and operable until the first week in October.

A second major problem area was evidenced during this period with control of the travel air lift sludge collector in the final clarifier. It was difficult to control the return sludge rates to less than ninety percent of the average daily flow because it was necessary to throttle the air close to lower limit where no air lift would occur. Installation of a time clock and solenoid valve allowed the return rate to approach thirty percent of the average daily flow.

Flow Scheme No. 1 was continued until July 1, 1968. During the period of May 1, 1968, until July 1, 1968, the pilot plant operated erratically. Because of the discontinuity of operation, no data with any degree of reliability can be claimed. However, when the activated sludge system was

operating properly, the trickling filter and final clarifier did not render any significant change in BOD removal. When the activated sludge system produced a poor quality effluent, the trickling filter made a significant removal. A review of all data available for this flow period showed the only continuity to be discontinuity. Presented in Figure 15 is a plot of the mixed liquor suspended solids versus time which is shown only to indicate the variability of the process. Preliminary plots of loading rates versus effluent BOD were determined to be of no value due to the fact that data points did not coincide and the data was incomplete. Table 2 shows the mean, highest and lowest value for Mixed Liquor Suspended Solids, BOD, Suspended Solids, COD, Ammonia, and Nitrate for selected sampling points as indicated.

Observations made during the two-month evaluation are as follows:

1. The trickling filter appeared to disperse the activated sludge floc and destroyed the good settling characteristics of activated sludge.
2. A definite increase in dissolved oxygen through the trickling filter was observed and was about 2 mg/l.

After completing operation of Flow Scheme No. 1 on July 1, 1968, the aeration tank and clarifiers were drained for routine inspection. The interior of the tanks were in good condition with only very small amounts of sand in the bottom. This was considered as a minor problem and the sand was removed. Additionally, the semifine bubble diffusers were replaced as described earlier, in an effort to reduce the excessive blower head. The drawing of the replacement diffuser was shown in Figure 11.

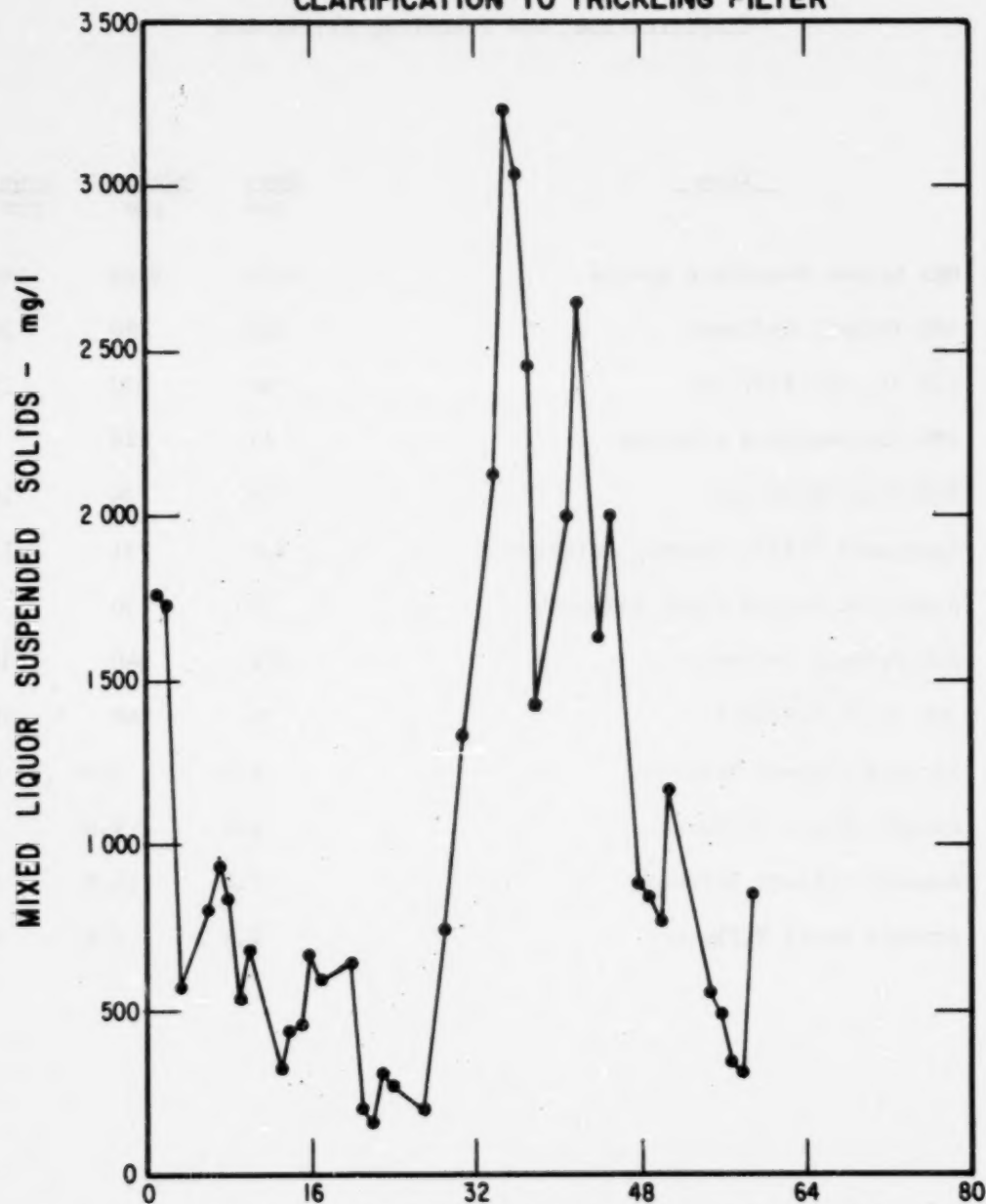
Activated Sludge and Trickling Filter

Flow Scheme No. 2 was previously shown in Figure 2. This flow scheme involved passing the mixed liquor from the aeration tank directly over the trickling filter and then to the final clarifier from where the settled sludge was returned to the activated sludge system.

The pilot plant was returned to service on Thursday, July 11, 1968. Between July 11 and July 29, 1968, considerable difficulty was experienced in trying to maintain the level of solids in the mixed liquor. This was attributed to the inability of the activated sludge to settle after passing through the trickling filter, which reduced the volume of return sludge and caused a decrease in mixed liquor solids.

During the period between July 30 and September 18, 1968, numerous attempts were made to build up the mixed liquor suspended solids by providing intermittent clarification between the aeration tank and the trickling filter. When this was done the solids could be increased in the aeration tank due to efficient settling in the clarifier. However, upon bypassing of the intermediate clarifier and applying the mixed liquor directly on the trickling filter, the solids level in the aeration tank would immediately drop, and the final clarifier would lose solids due to the resultant poor floc settling characteristics.

ACTIVATED SLUDGE WITH INTERMEDIATE
CLARIFICATION TO TRICKLING FILTER



TIME IN DAYS - MAY 1, 1968 THRU JULY 1, 1968
FIGURE 15-MIXED LIQUOR SUSPENDED SOLIDS

TABLE 2

Summary Data For Activated Sludge,
Clarification, and Trickling Filtration

<u>Item</u>	<u>Mean ppm</u>	<u>Highest ppm</u>	<u>Lowest ppm</u>
1. Mix Liquor Suspended Solids	1050	3228	160
2. BOD Primary Influent	150	250	32
3. BOD Primary Effluent	102	230	38
4. BOD Intermediate Effluent	49	128	5
5. BOD Final Effluent	16	34	10
6. Suspended Solids Primary Influent	232	731	112
7. Suspended Solids Final Effluent	15	30	2
8. COD Primary Influent	316	540	150
9. COD Final Effluent	74	100	50
10. Nitrate Primary Influent	1.0	1.6	0.5
11. Nitrate Final Effluent	4.4	9.0	1.0
12. Ammonia Primary Influent	8.4	14.0	2.6
13. Ammonia Final Effluent	2.5	4.0	0.5

Figure 16 is a plot of the mixed liquor suspended solids versus time with and without the use of intermediate clarification. Two distinct patterns for the mixed liquor suspended solids are evident and reflect the process instability when applying mixed liquor to the trickling filter. Tables 3 and 4 present the mean, highest and lowest values for BOD, COD, MLSS, nitrate, ammonia and suspended solids for samples taken during both flow periods, July 11 through July 29, and July 30 through September 18.

In studying the data available it was evident that the mixed liquor floc settling characteristics were not as good as that occurring during operation of Flow Scheme No. 1 and definitely poorer than that of a normal activated sludge process. Figure 17 was prepared to show the relationship between primary influent and final effluent suspended solids. The high suspended solid level in the final effluent is indicative of the poor floc settling quality after passing thru the trickling filter.

Flow Scheme No. 2 was finally abandoned on August 18, 1968, with incomplete and conflicting data due to the process control problems. However, the results did indicate that nothing can be gained by passing mixed liquor over a trickling filter; the activated sludge floc does not coalesce in such a process, but tends to break apart and disperse.

Trickling Filter Followed by Activated Sludge

Flow Scheme No. 3 was previously shown in Figure 3. This flow scheme consisted of primary sedimentation, trickling filtration, activated sludge, and final clarification. Operation was initiated on September 19, 1968, to establish a biological growth on the trickling filter prior to obtaining data. During the first week of October, 1968, automatic valve control equipment was installed on the blower discharge butterfly valve and interconnected with the dissolved oxygen monitoring system (see Figure 12) to permit more precise control of oxygenation in the aeration system. On October 11, 1968, new probes were installed in the dissolved oxygen system due to the severe fluctuations observed in dissolved oxygen levels. The new probes corrected the problem and the dissolved oxygen system functioned satisfactorily.

After the first several days of operation it was noted that the clarity of the final effluent varied considerably. This was attributed to uneven energy dissipation in the clarifier inlet diffuser which resulted in density currents and short circuiting. A moveable baffle was installed on October 14, 1968, and positioned at the two-thirds point from the inlet side. This location was selected by observing floc settling and subsequent dye tests. Operation for the remainder of October, November and December, 1968, reflected a near balance of equipment and controls.

This flow scheme continued until January 25, 1969, when the Eastside Water Reclamation Facility and the pilot plant were inundated by flooding of the Santa Clara River (2). The estimated peak discharge of 165,000 cubic feet per second from a drainage area of about 1,600 square miles, was the largest flood ever recorded in the Santa Clara River. The flooding was a result of heavy rainfall over a period of 8 days which totaled approximately 15 inches.

ACTIVATED SLUDGE TO TRICKLING FILTER

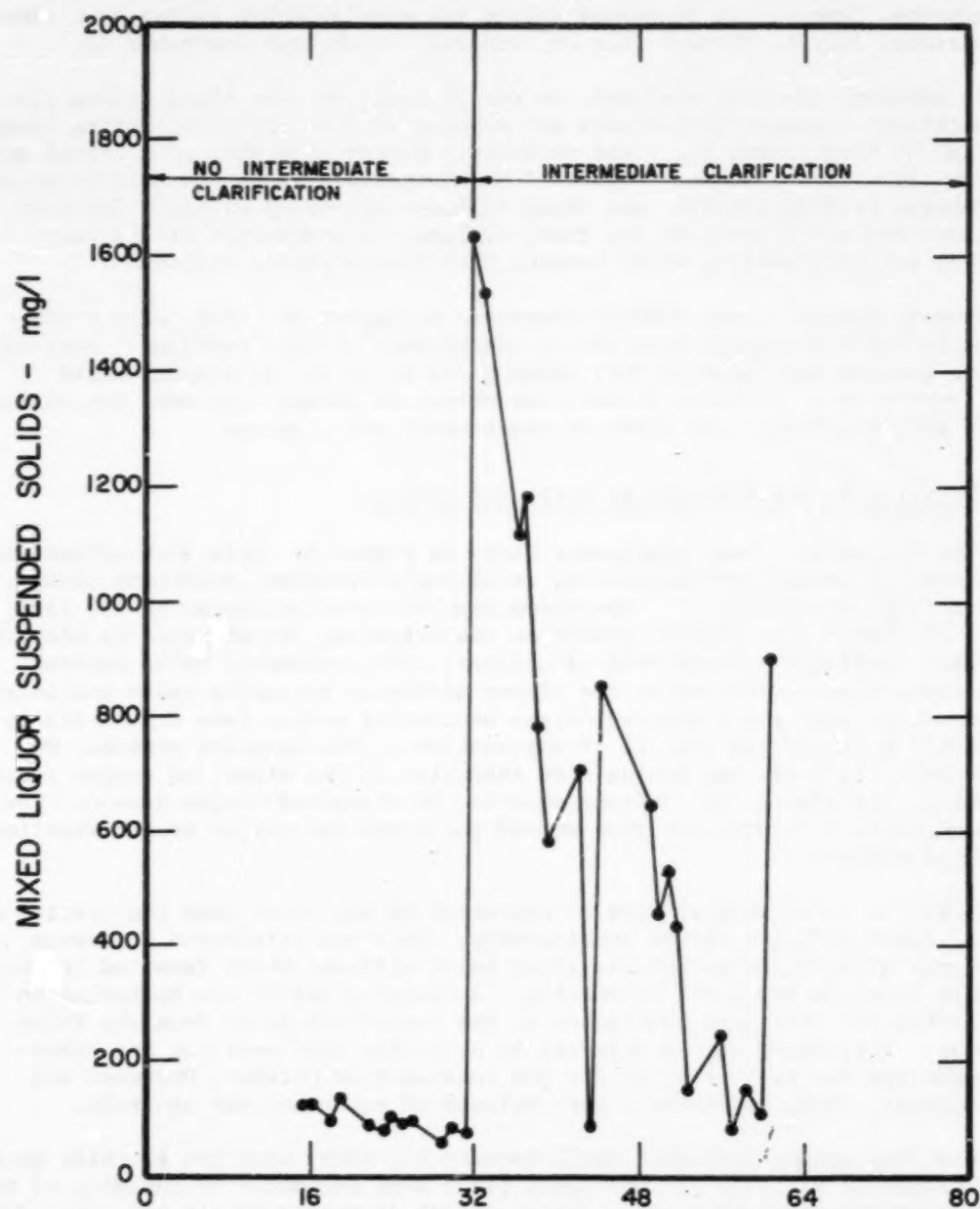


FIGURE 16-MIXED LIQUOR SUSPENDED SOLIDS

TABLE 3

Activated Sludge Followed by Trickling Filter

<u>Item</u>	<u>Mean</u> ppm	<u>Highest</u> ppm	<u>Lowest</u> ppm
1. Mix Liquor Suspended Solids	101	130	75
2. BOD Primary Influent	132	200	66
3. BOD Primary Effluent	81	85	76
4. BOD Intermediate Effluent	-	-	-
5. BOD Final Effluent	89	145	41
6. Suspended Solids Primary Influent	195	230	160
7. Suspended Solids Final Effluent	56	70	40
8. COD Primary Influent	402	630	300
9. COD Final Effluent	202	500	110
10. Nitrate Primary Influent	1.7	1.9	1.2
11. Nitrate Final Effluent	2.2	3.0	1.4
12. Ammonia Primary Influent	12.5	14.0	11.0
13. Ammonia Final Effluent	3.6	4.0	3.2

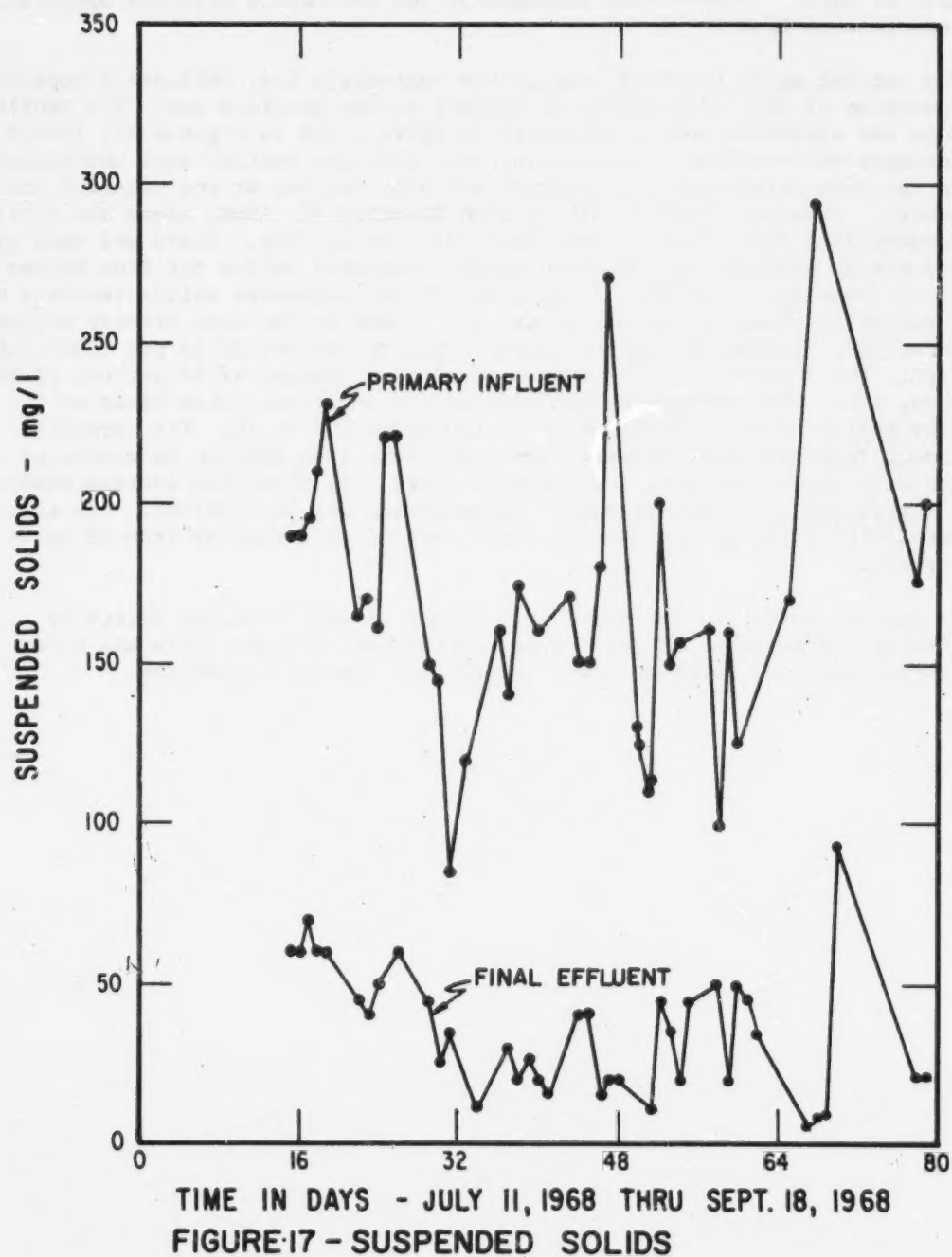
TABLE 4*

Activated Sludge with Intermittent Clarification Followed By
Trickling Filter

<u>Item</u>	<u>Mean</u> ppm	<u>Highest</u> ppm	<u>Lowest</u> ppm
1. Mix Liquor Suspended Solids	561	1630	55
2. BOD Primary Influent	148	230	100
3. BOD Primary Effluent	104	150	50
4. BOD Intermediate Effluent	181	300	45
5. BOD Final Effluent	27	92	5
6. Suspended Solids Primary Influent	159	295	85
7. Suspended Solids Final Effluent	29	92	5
8. COD Primary Influent	319	510	130
9. COD Final Effluent	105	230	33
10. Nitrate Primary Influent		No Data	
11. Nitrate Final Effluent		No Data	
12. Ammonia Primary Influent		No Data	
13. Ammonia Final Effluent		No Data	

*The data in this table is related to that in Table 3; however, intermittent clarification was used to try and build up Mixed Liquor Suspended Solids before application to the trickling filter.

ACTIVATED SLUDGE TO TRICKLING FILTER



A second major flood occurred on February 25, 1969, after approximately 7 inches of rainfall in 3 days. The estimated peak discharge was 152,000 cubic feet per second. The Eastside Water Reclamation Facility was hit even harder than during the first flood and was under approximately five feet of water. Substantial portions of the laboratory data and operating reports were lost.

The records which remained, namely the operator's log, indicate a superior operation of this flow scheme in respect to the previous two. The available data was evaluated and is presented in Table 5 and in Figures 18, 19 and 20. Attempts to correlate loading rates with effluent quality were unsuccessful as the data points did not coincide and data was not at the required frequency. Data is included only through December 31, 1968, since the available January 1969 data prior to the flood was very sketchy. There was much greater success in controlling the mixed liquor suspended solids for Flow Scheme No.3 as is shown in Figure 18. Also, good BOD and suspended solids removals were obtained as shown in Figures 19 and 20. Based on the mean primary effluent 5-day BOD, loading on the trickling filter system was 39 lb per 1,000 cubic feet. The trickling filter system removed an average of 62 percent of the 5-day BOD. The average loading rate on the aeration system based on the flow period mean was 24 lb of 5-day BOD per 1,000 cu.ft. The aeration system loadings were extremely low and future runs were to be conducted at higher rates by baffling the aeration tank. The 5-day BOD average removal accomplished with the activated sludge system was 17.5 lb/day. The activated sludge system increased overall removal efficiencies from 62 to 86 percent.

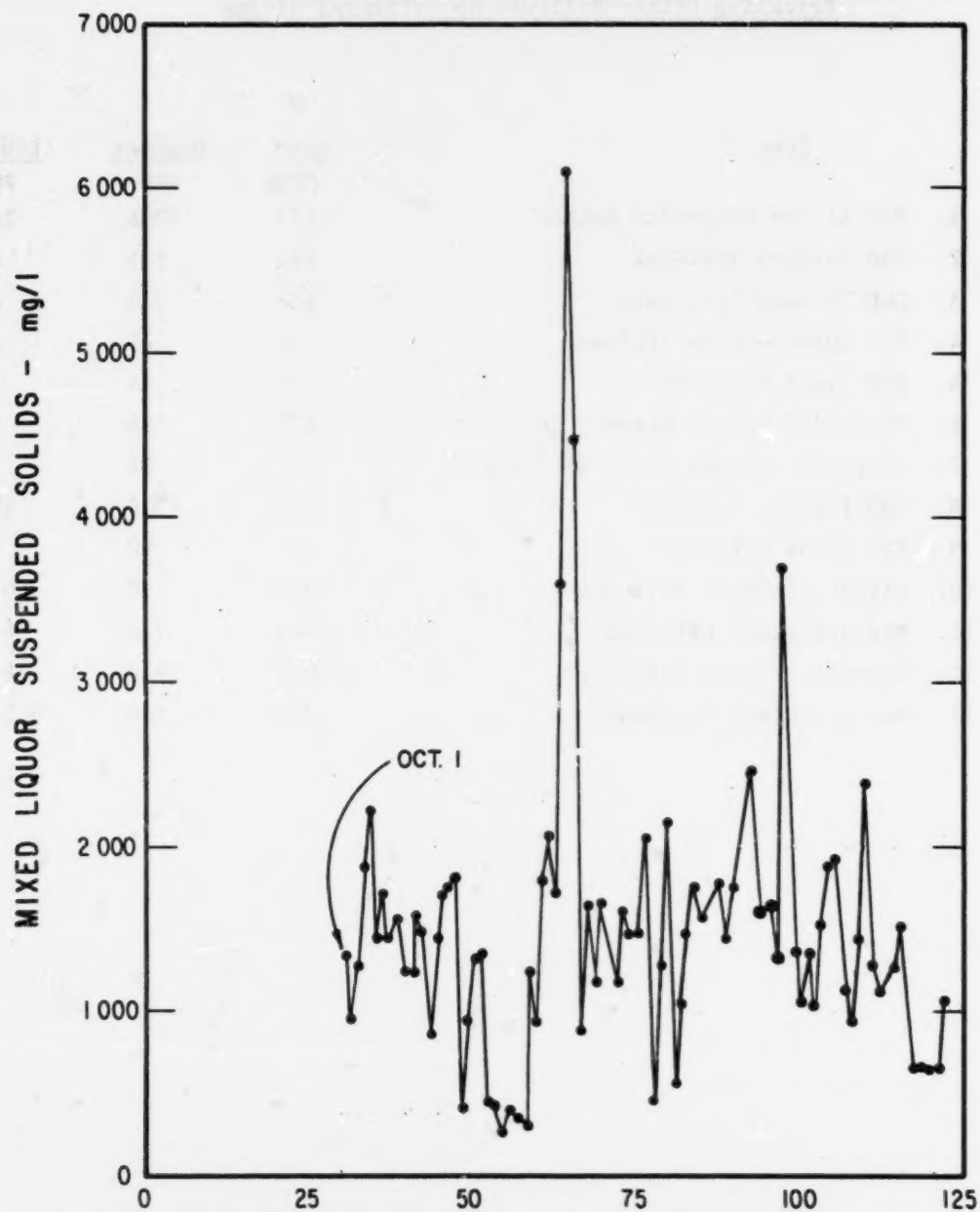
It was the intent to increase the loadings on the trickling filter by closing off portions of the rotary distributor; however, this was never accomplished due to pilot plant damage as a result of flooding.

TABLE 5

Trickling Filter Followed by Activated Sludge

<u>Item</u>	<u>Mean</u> ppm	<u>Highest</u> ppm	<u>Lowest</u> ppm
1. Mix Liquor Suspended Solids	1473	6096	264
2. BOD Primary Influent	221	672	63
3. BOD Primary Effluent	117	210	42
4. BOD Intermediate Effluent	45	65	17
5. BOD Final Effluent	17	64	2
6. Suspended Solids Primary Influent	178	586	77
7. Suspended Solids Final Effluent	11	36	1
8. COD Primary Influent	287	510	100
9. COD Final Effluent	41	90	10
10. Nitrate Primary Influent	0.6	1.0	0.4
11. Nitrate Final Effluent	6.6	7.0	6.1
12. Ammonia Primary Influent	10.6	14.6	8.1
13. Ammonia Final Effluent	3.4	4.0	2.8

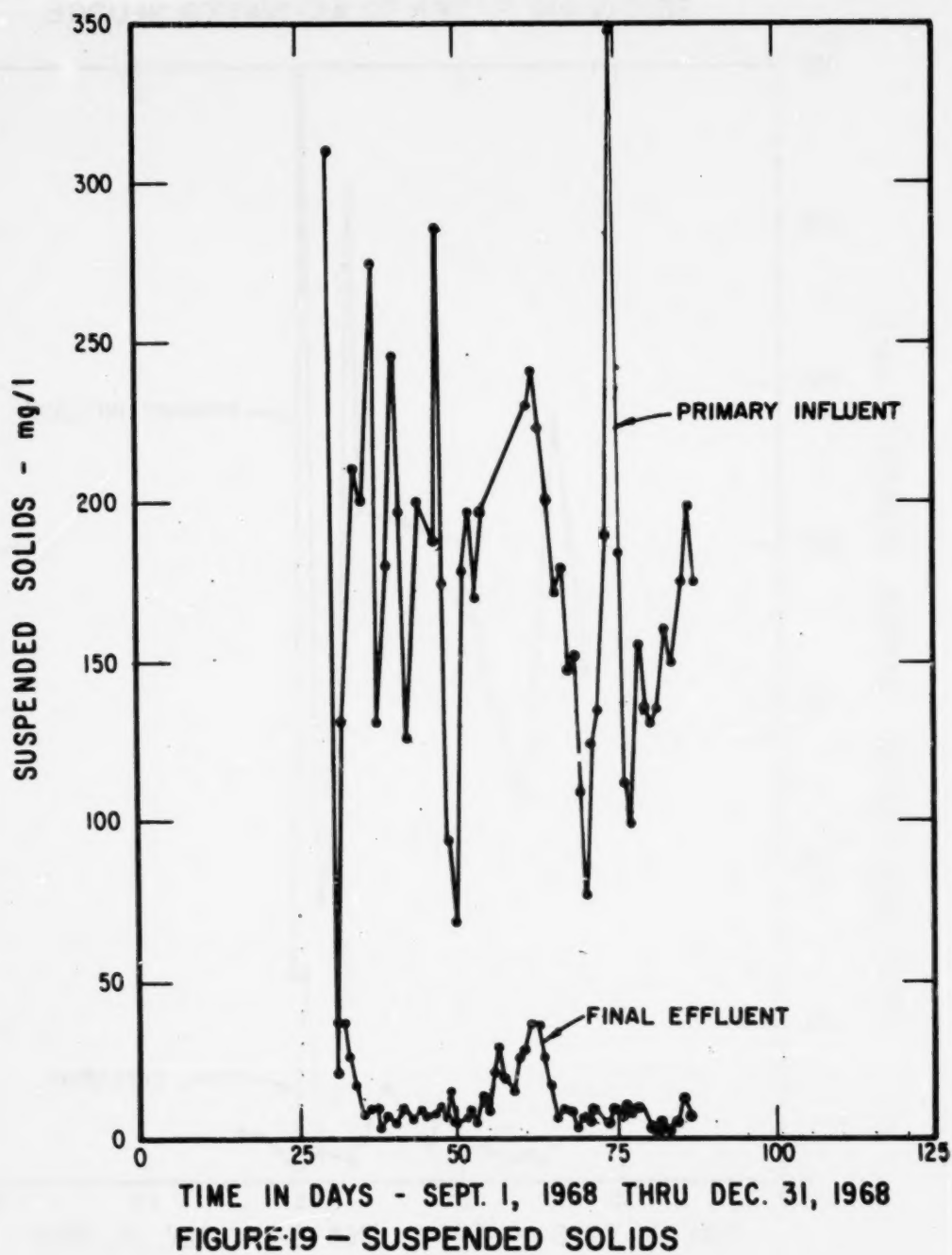
TRICKLING FILTER TO ACTIVATED SLUDGE



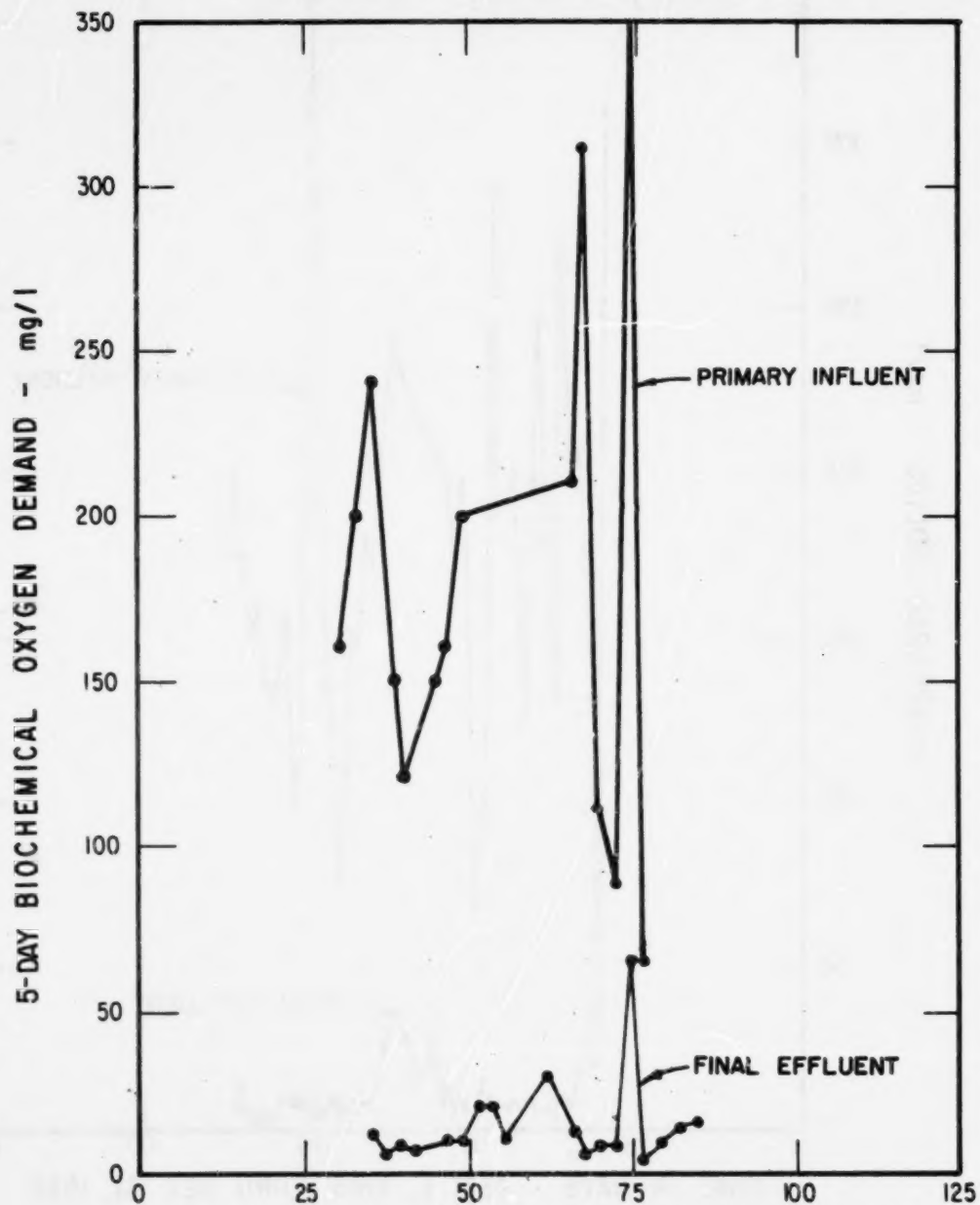
TIME IN DAYS - SEPT. 1, 1968 THRU DEC. 31, 1968

FIGURE-18 - MIXED LIQUOR SUSPENDED SOLIDS

TRICKLING FILTER TO ACTIVATED SLUDGE



TRICKLING FILTER TO ACTIVATED SLUDGE



TIME IN DAYS - SEPT 1, 1968 THRU DEC. 31, 1968

FIGURE 20-BIOCHEMICAL OXYGEN DEMAND

SECTION VI

DISCUSSION OF RESULTS

The failure to stabilize the pilot plant operation in the first two of the three flow schemes investigated was primarily attributed to mechanical problems, an inadequate sampling schedule and the disruption of the activated floc settling characteristics by the trickling filter. Application of mixed liquor directly onto the trickling filter completely dispersed the activated sludge causing loss of solids to the final effluent.

From the three flow schemes evaluated, the trickling filter preceding the activated sludge appears to be best mode of operation. BOD loading and other design data are not available to adequately define the operational parameters for this flow scheme. However, the data does indicate that the process of trickling filtration preceding activated sludge was stabilized which resulted in mean BOD, suspended solids, and COD removals of 92.5, 85.5 and 93.8 percent respectively.

SECTION VII

ACKNOWLEDGMENTS

The support of the City Manager of San Buenaventura, Mr. Edward E. McCombs and the City Council, Mayor Al Albinger, Thomas L. Bailey, David D. Eaton, Samuel Neil, Eugene C. Kountz, Gordon Lindsay and Barbara Udsen is acknowledged with sincere thanks. Mr. Paul E. Owen, Public Works Director, was the Project Administrative Officer and provided valuable assistance.

The construction and operation of the pilot plant was under the direction of David L. Sullivan, Sanitation Superintendent, who also served as Grant Project Director. The operation of the pilot plant was under the direction of the Plant Operator, Thomas L. Sutton. All Maintenance and part of the construction was under the direction of Roger L. Messersmith, Maintenance Supervisor. The testing and analytical work was done by Thomas Wieland, Sanitation Chemist. Boyle Engineering was the Consultant on the Project.

The support of the Project by the Office of Research and Monitoring, Environmental Protection Agency, and the help by Mr. John N. English, the Grant Project Officer, is acknowledged with sincere thanks.

SECTION VIII

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1. Gehm, H. W. and Gellman, I., "Practice, Research, and Development in Biological Oxidation of Pulp and Papermill Effluents," Journal Water Pollution Control Association, October, 1965.
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1	Accession Number	2	Subject Field & Group	SELECTED WATER RESOURCES ABSTRACTS INPUT TRANSACTION FORM
	W		05D	

5	Organization
	City of San Buenaventura, California

6	Title
	Integrated Activated Sludge Biological Filter Process

10	Author(s)	16	Project Designation
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		21	Note

22	Citation

23	Descriptors (Starred First)
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25	Identifiers (Starred First)
	*Upgrading Wastewater Treatment, Combined Activated Sludge-Trickling Filtration

27	Abstract A 75,000 gallon per day pilot plant was constructed at the City of San Buenaventura's Eastside Water Reclamation Facility, to evaluate the feasibility of treating domestic wastewaters by combining the two established processes of trickling filtration and complete mixed activated sludge. These processes were combined and evaluated according to the following three flow schemes:
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1. Primary Sedimentation, Activated Sludge, Intermediate Sedimentation, Trickling Filter, and Final Sedimentation.
2. Primary Sedimentation, Activated Sludge, Trickling Filter, and Final Sedimentation.
3. Primary Sedimentation, Trickling Filter, Activated Sludge, and Final Sedimentation.

Mechanical problems with equipment and the lack of process control during operation of Flow Scheme No. 1 were responsible for the unstable conditions and unreliable data.

The performance of Flow Scheme No. 2 was seriously affected by the lack of concentrated return activated sludge due to floc dispersal, and loss of solids to the final effluent as a result of the mixed liquor passing over the trickling filter.

Flow Scheme No. 3 was stabilized and meaningful data was in the process of being collected when a major flood on the Santa Clara River inundated the entire water reclamation facility and pilot plant. Preliminary data indicated that this flow scheme is the most promising combination of the trickling filtration and activated sludge processes.

Abstractor John N. English	Institution Environmental Protection Agency
WN 102 (REV. JULY 1969) WRSIC	SEND, WITH COPY OF DOCUMENT, TO: WATER RESOURCES SCIENTIFIC INFORMATION CENTER U.S. DEPARTMENT OF THE INTERIOR WASHINGTON, D. C. 20240